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TITLE THE SENSITIVITY OF ROLLING TEXTURE PREDICTIONS TO THE ASSUMPTIONS USED

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THE SENSITIVITY OF ROLLING TEXTURE PREDICTIONS

TO THE ASSUMPTIONS USED[†]

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It is demonstrated for the case of rolling textures that simulation results are rather insensitive to some assumptions (as claimed by Leffers), but rather sensitive to others. This degree of sensitivity depends strongly on the total strain simulated. The most crucial influence is exerted by the introduction of relaxed constraints for flat grains.

Introduction

In a separate panelist's contribution, Leffers[1] reports the results of a limited 'round robin' for deformations textures. His first set of results relates to the orientation changes of 15 grains in tension, the second to rolling (plane-strain compression) of a polycrystal to a reduction of 50%. The conclusion is reached that all programs give similar results, for a wide range of assumptions made. We have undertaken a similar study, using our own program only, but inserting different assumptions, and we come to a different conclusion. We report here on the case of rolling only.

Code

The following results were obtained with the Los Alamos Polycrystal Plasticity code (LApp, version 4.8) developed by G.R. Canova, C. Tomé, and the author. The starting texture consisted of 800 randomly oriented grains. For each grain, a Bishop-Hill solution was first obtained from the known single-crystal yield surface for FCC materials. The stress obtained was then used as an initial guess in a Newton-Raphson scheme to solve a power-law kinetic relation. The rate sensitivity used was sometimes 0.03, sometimes 0.01, with no difference ever detected between them; a rate sensitivity of 1/3, however, did produce substantial differences.

The slip system distribution, and the resulting orientation changes, were obtained both by the rate-sensitive method described above, and by the classical 'averaging of Taylor solutions'. 'Relaxed constraints' were introduced gradually with strain, as a function of the aspect ratio of the grain shape. For the two components in which the strains were relaxed, the stress was assumed to be zero throughout the body. Four levels of strain were simulated; they are quoted in terms of vonMises equivalent strains of 1.0, 2.0, 2.5, and 3.0, corresponding to reductions of 58, 82, 89, and 93%. The grain fraction operating under relaxed constraints was 0.1, 0.6, 0.75, and 0.85, respectively, for the four strain levels. All textures are displayed only as (111) pole figures in stereographic projection.

Full Constraints versus Relaxed Constraints

Figure 1 shows the results for the lowest and highest strain (1.0 and 3.0, respectively). At the lowest strain (a), full constraints are appropriate for all models. The 'Taylor component' (T) is clearly visible. At the highest strain under full constraints (b), the texture has remained qualitatively the same, only become sharper. Under relaxed constraints, however, the situation is qualitatively changed (c): both the 'copper component' (C) and the 'S component' (S) have appeared. This was the important result first derived by Mecking and Honneff[2]. One may argue about subtleties of the match of these textures to experimental ones[3], but there is no doubt that Fig. 1(c) is closer to the experimental results than Fig. 1(b).
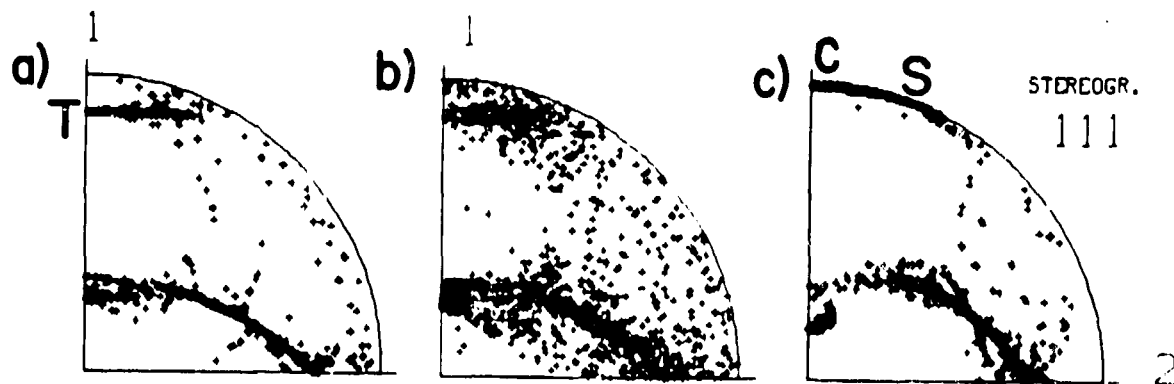

FIG. 1 - Predicted (111) pole figure after plane-strain compr :sion to a vonMises equivalent strain of 1.0 (a) and 3.0 (b,c). Assumption of Full Constraints (a,b) or Relaxed Constraints (c).

Averaging versus Rate Sensitivity

At strains of 1.0 and 3.0 (Fig. 1), the results were statistically indistinguishable, regardless of whether the averaging of all the extreme solutions allowed by the Taylor model was applied, or the rate-sensitive correction of the Bishop-Hill stress. The transition from the low to the high strain, however, does depend on the method of 'ambiguity resolution': Figures 2(a) and 2(b) show the results of an averaging calculation at vonMises strains of 2.0 and 2.5, respectively, while Fig. 2(c) and (d) display the corresponding results with (low) rate sensitivity. The transition is smoother in the latter case; in the former, a dual texture appears at ε=2.5 (Fig. 2(b)). (If full constraints had benn used through- out, there would not have been any qualitative change with strain at all, and thus the averaging and rate-sensitive methods would have given similar results.) All in all, then, when there is a difference, the rate-sensitive solution seems the more satisfactory.
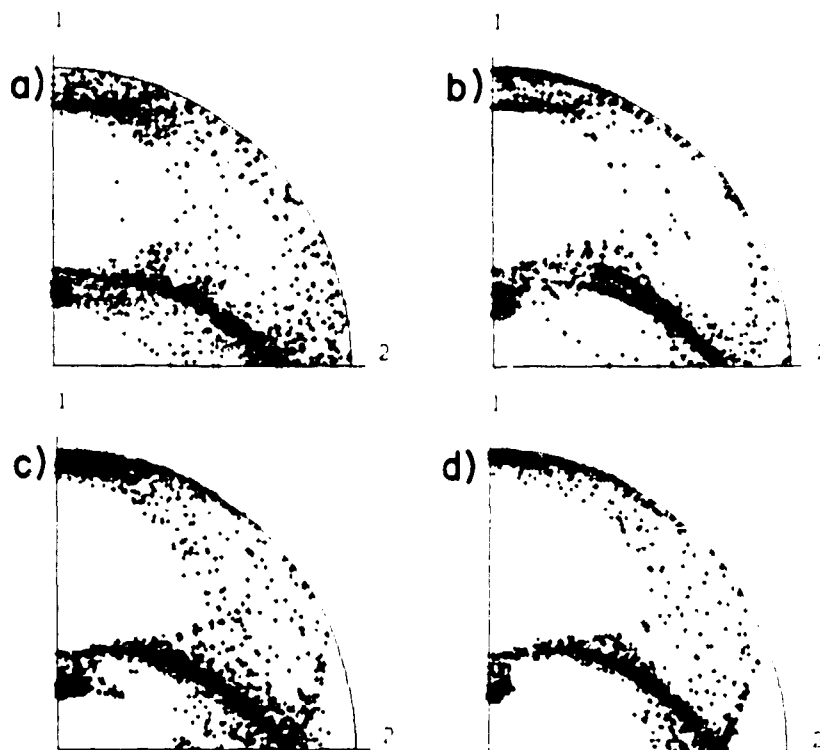
FIG. 2 – Predicted (111) pole figures after plane-strain compression to a
vonMIses equivalent strain of 2.0 (a,c) and 2.5 (b,d). Top row: obtained by
averaging all extreme Taylor solutions; bottom row: using rate sensitivity.

High Rate Sensitivity

A rate sensitivity of 1/3, as it is expected in 'Class I' alloys at high
temperature (while the deformation geometry is still controlled by disloc-
ation glide, not climb), gives qualitatively different results from a rate
sensitivity of less than 0.03.[4] Figure 3 shows, for c-1.0 and c-3.0, that
the 'copper component' has shifted part-way back to the 'Taylor component',
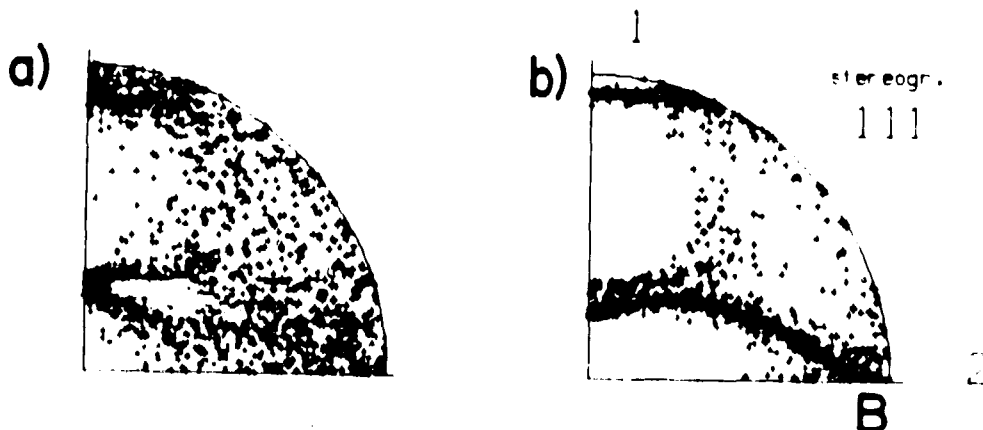and that a 'brass component' (B) appears right from the beginning.

FIG. 3 – Predicted (111) pole figure after plane-strain compression to a
vonMIses equivalent strain of 1.0 (a) and 3.0 (b), when the rate sensitivity
of the single-slip flow stress is 1/3.

Conclusions

1. Rolling texture predictions are sensitive to the introduction of relaxed constraints, and better with than without.

2. In some strain regime, they are sensitive to the method of 'amb'.guity resolution', and are better using a finite (though very small) rate sensitivity than using averaging.

The major fault of most methods remains that the predicted textures are too sharp.

References

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